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Bisset

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(54) **BLOWOUT PREVENTOR ACTUATION TOOL**

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E21B 7/12 (2006.01)
E21B 33/035 (2006.01)
E21B 33/064 (2006.01)

(52) **U.S. Cl.**

CPC ***E21B 33/035*** (2013.01); ***E21B 33/0355*** (2013.01); ***E21B 33/064*** (2013.01)

(58) **Field of Classification Search**

CPC E21B 33/0355; E21B 33/064
USPC 166/344, 363, 368; 405/190, 191
See application file for complete search history.

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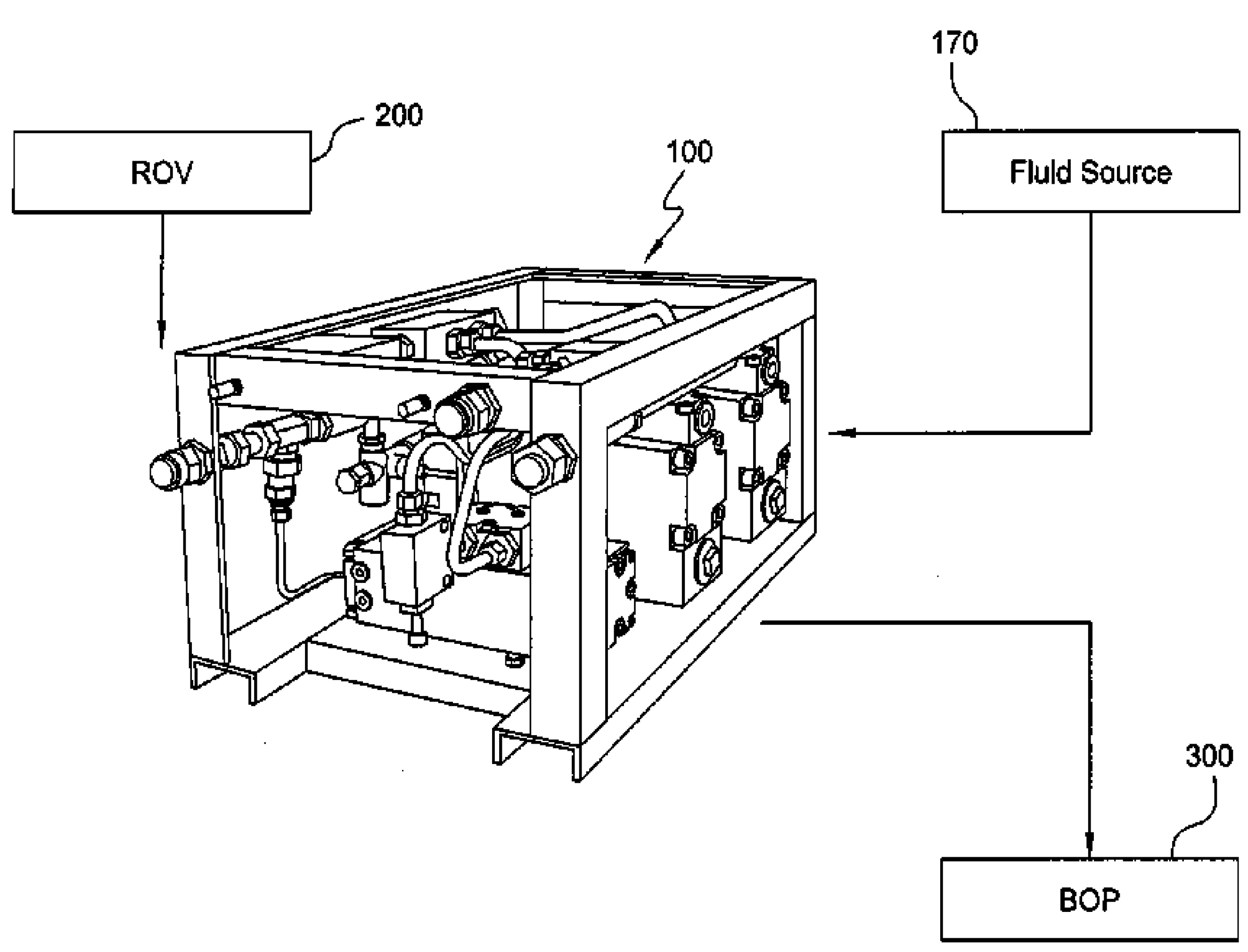
(57) **ABSTRACT**

A tool for actuating a blow out preventer includes one or more connections for receiving hydraulic power from a remotely operated vehicle ("ROV"), a first pump for increasing pressure of an operating fluid for the blowout preventer ("BOP"), a second pump for increasing flow rate of the operating fluid, and a conductor for transporting the operating fluid to the BOP. The tool rapidly increases the pressure and flow rate of the fluid flowing to the BOP, and the BOP may be rapidly closed.

20 Claims, 9 Drawing Sheets



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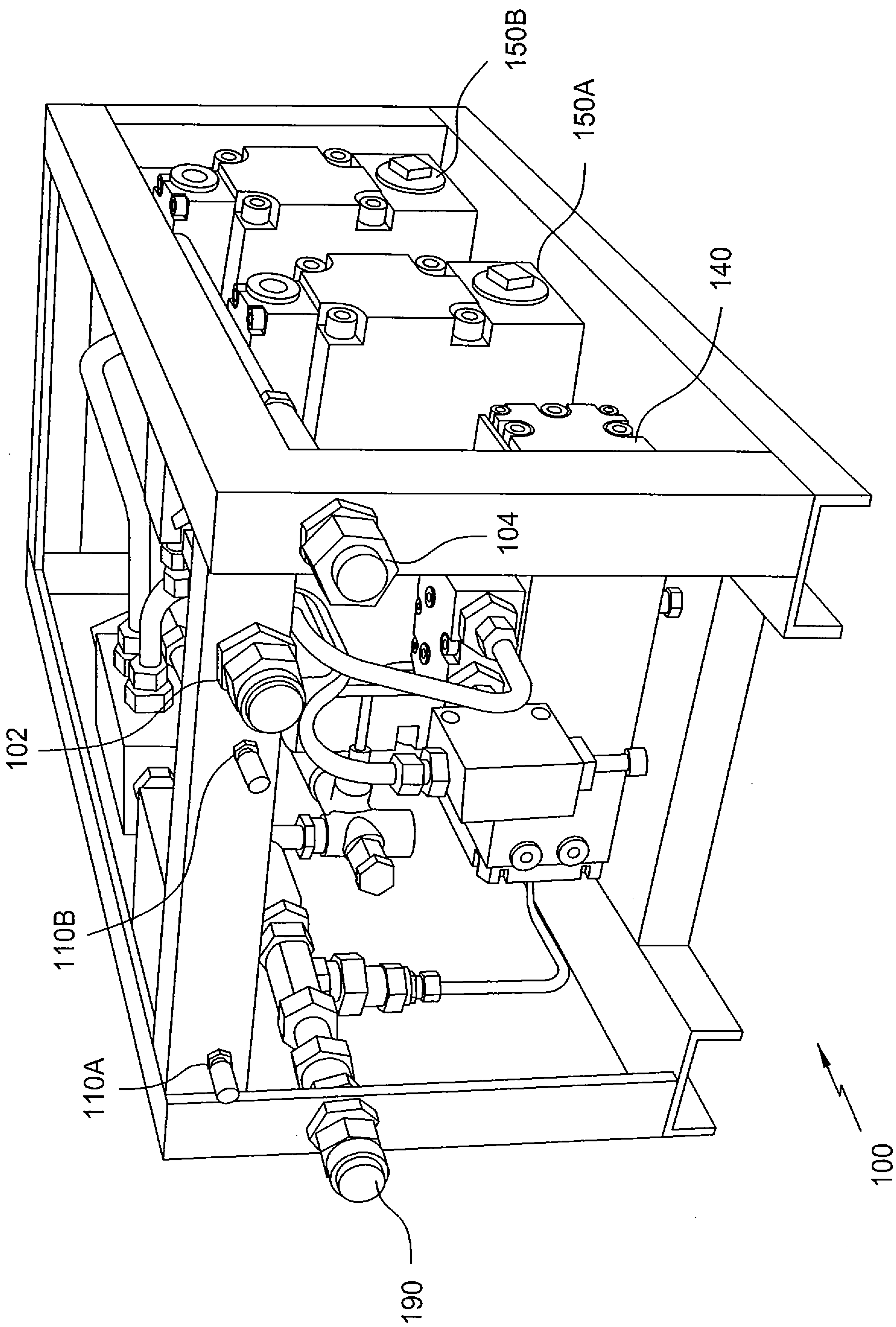
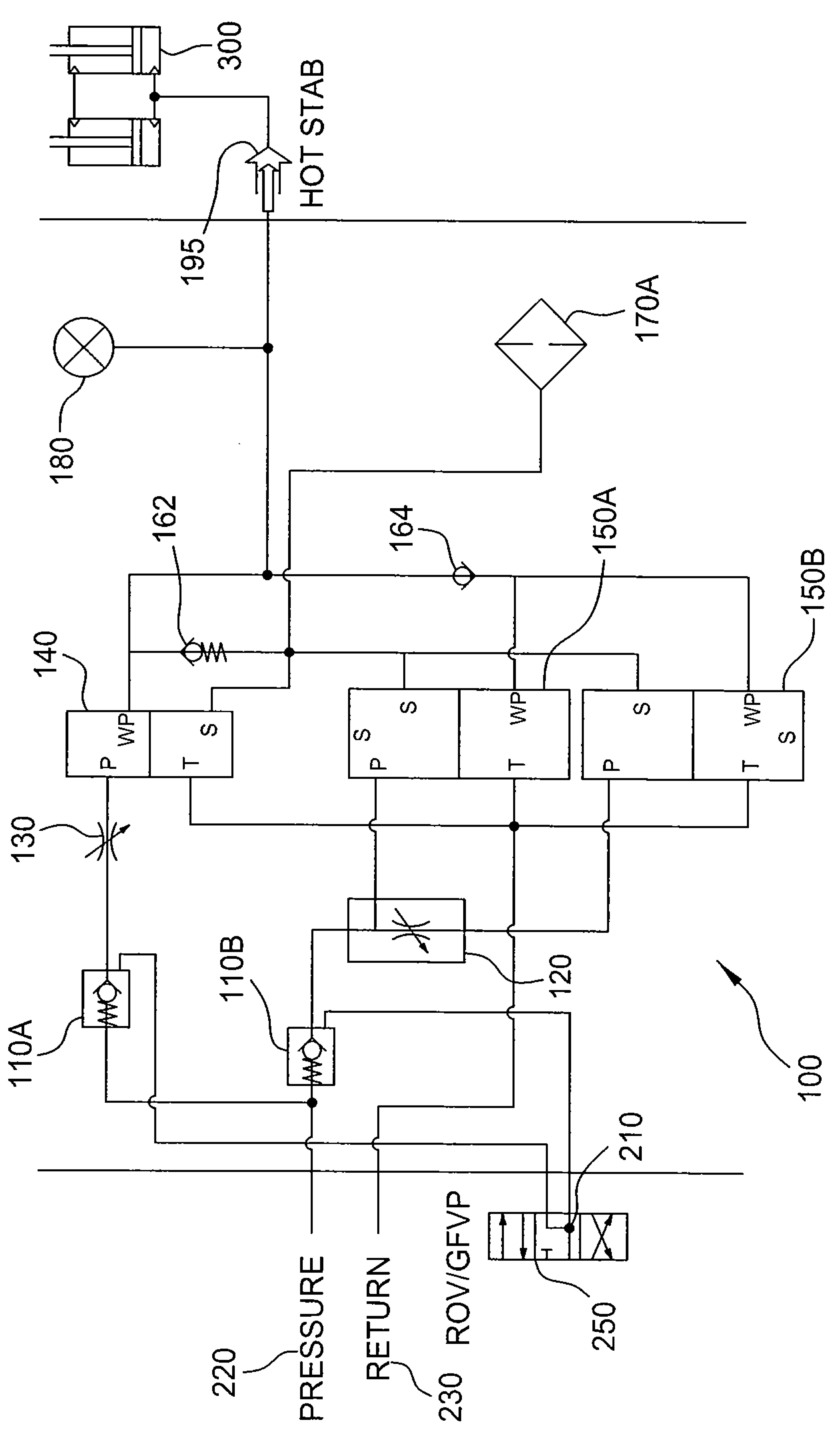


FIG. 1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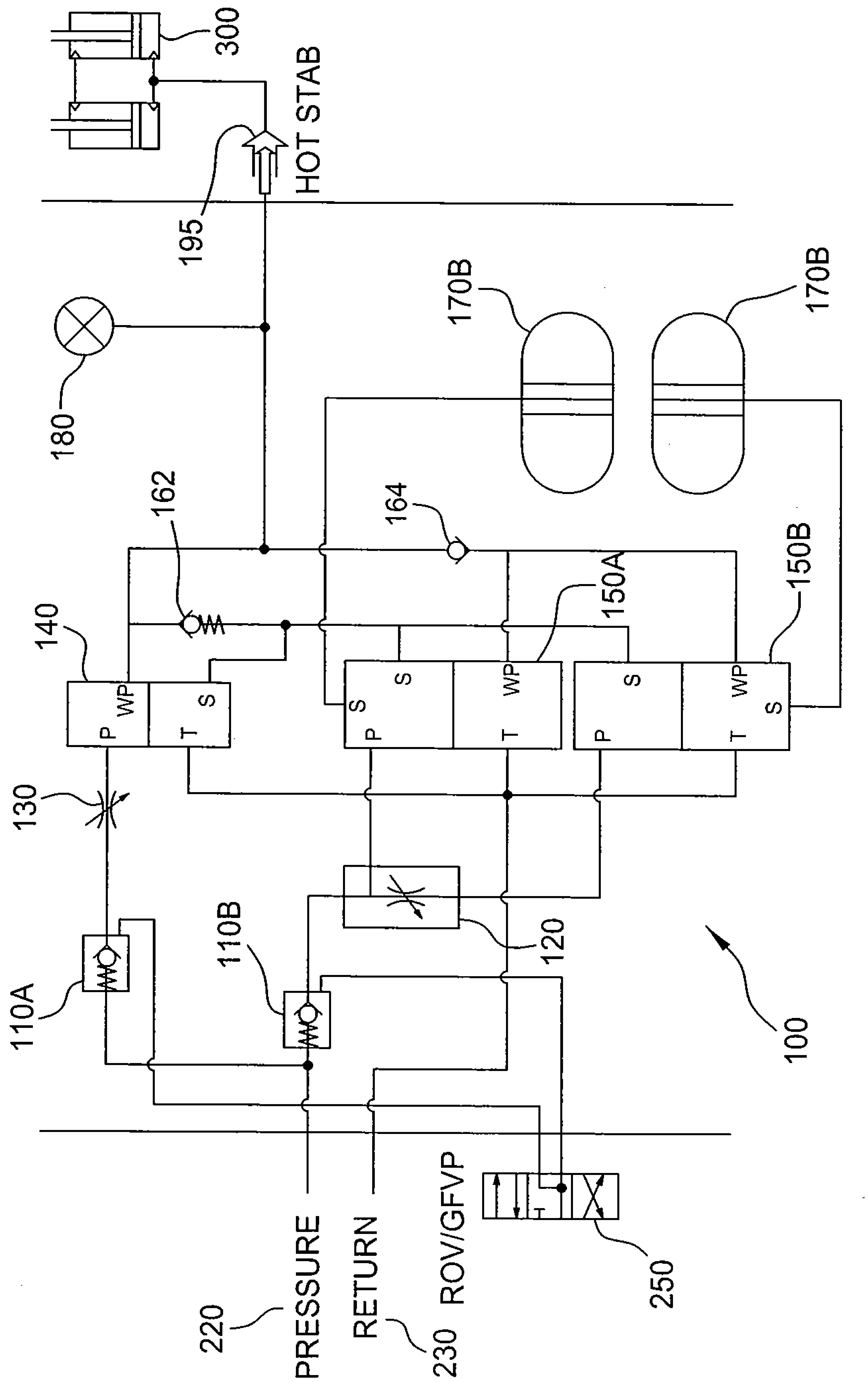
HOT STAB
195
180
170A
162
164
150A
150B
140
130
110A
110B
120
100
210
250
PRESSURE
RETURN
ROV/GFVP
220
230
P
WP
T
S

FIG. 2


300
HOT STAB
195
180
170B
170B
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140
P
WP
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150A
150B
130
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110B
120
100
PRESSURE
RETURN
ROV/GFVP
220
230
250

FIG. 3

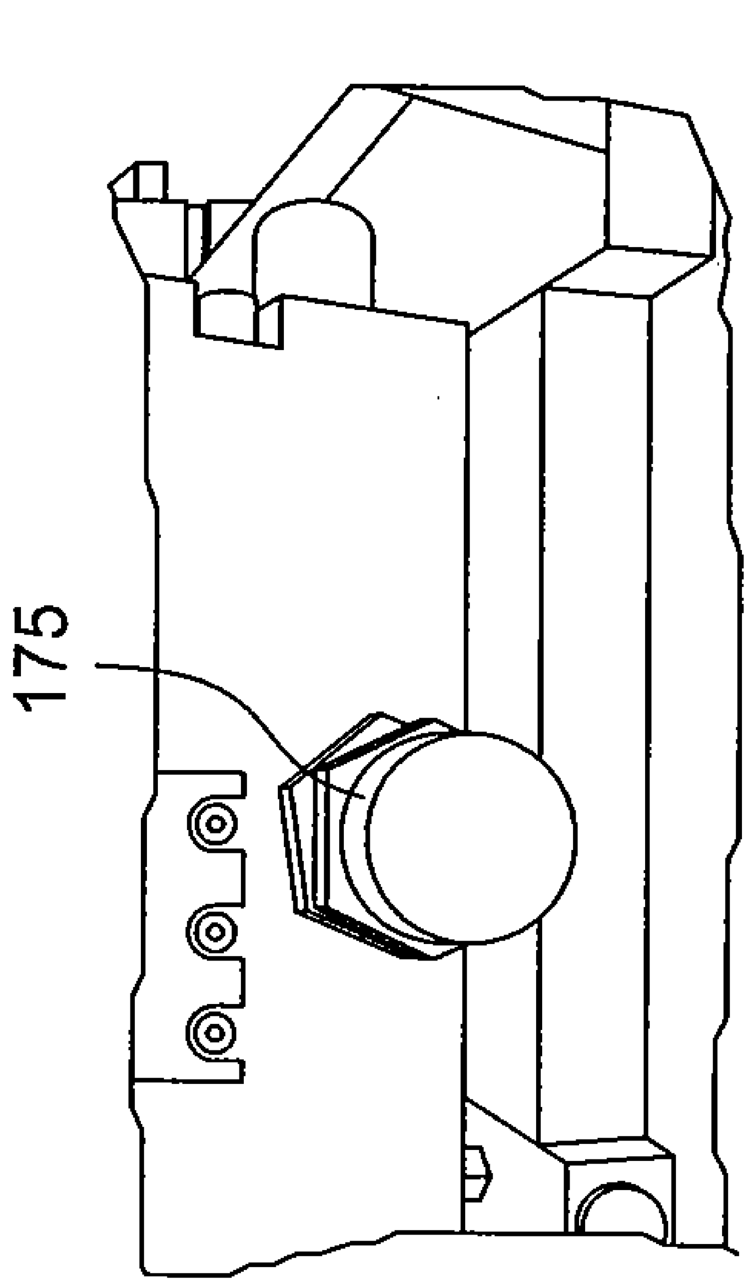

FIG. 5A

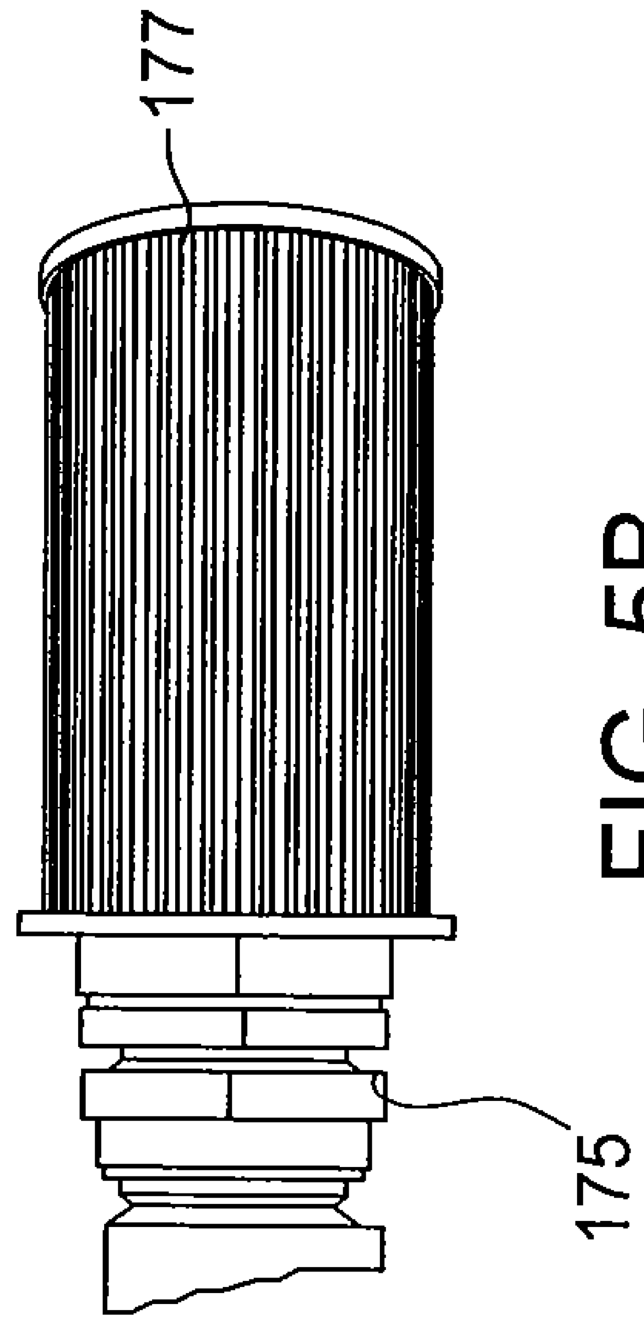

FIG. 5B

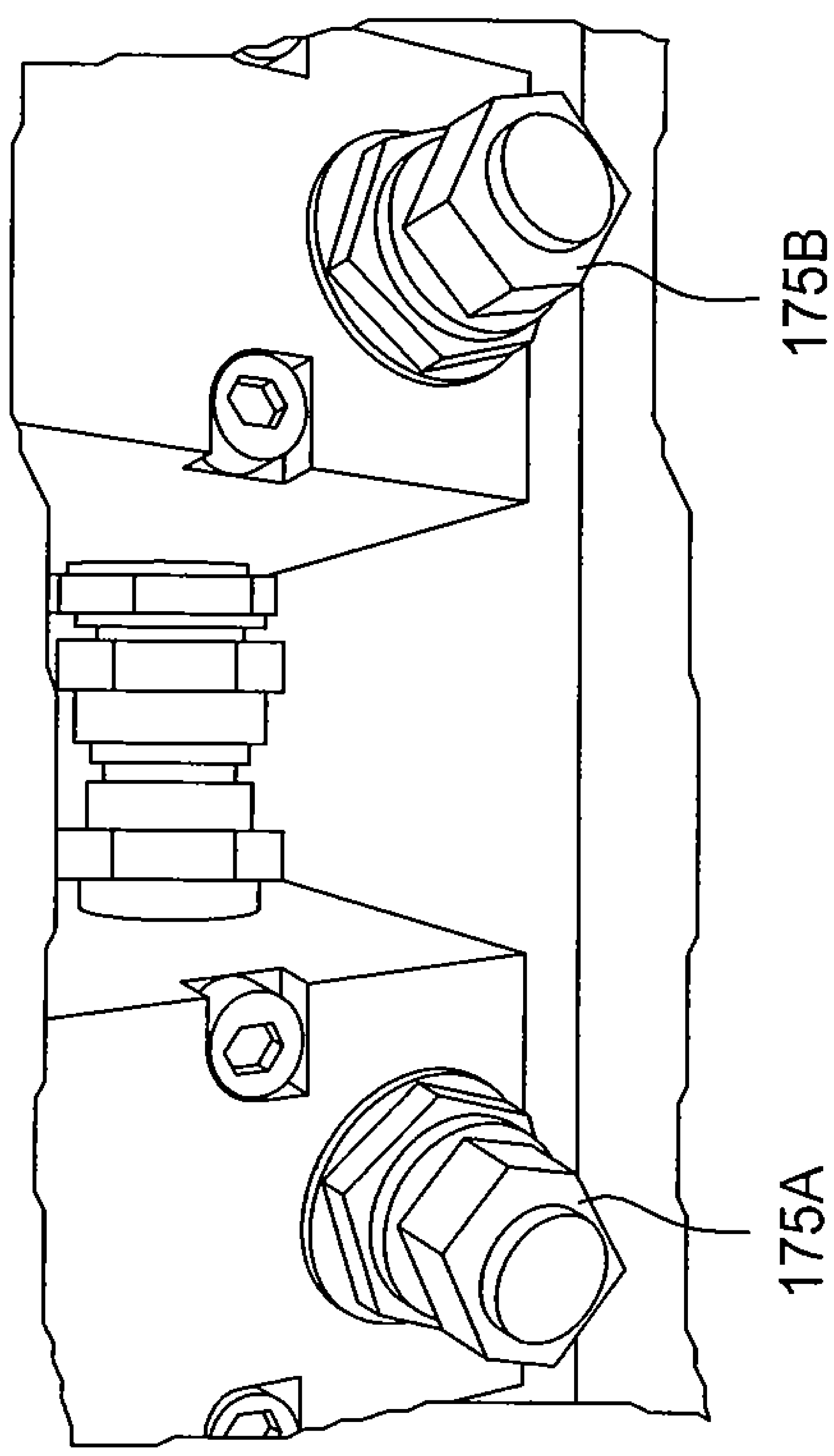

FIG. 4

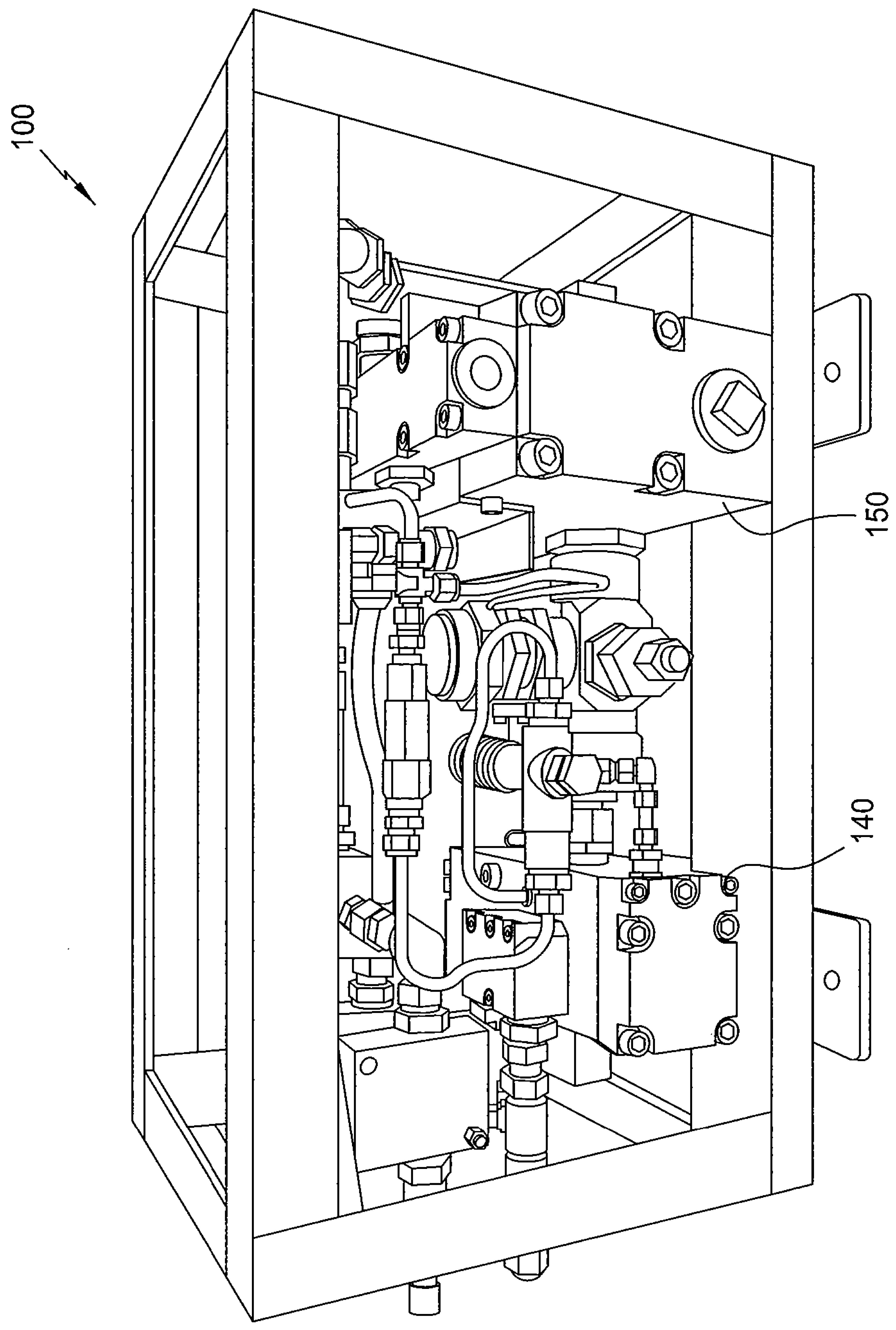

FIG. 6

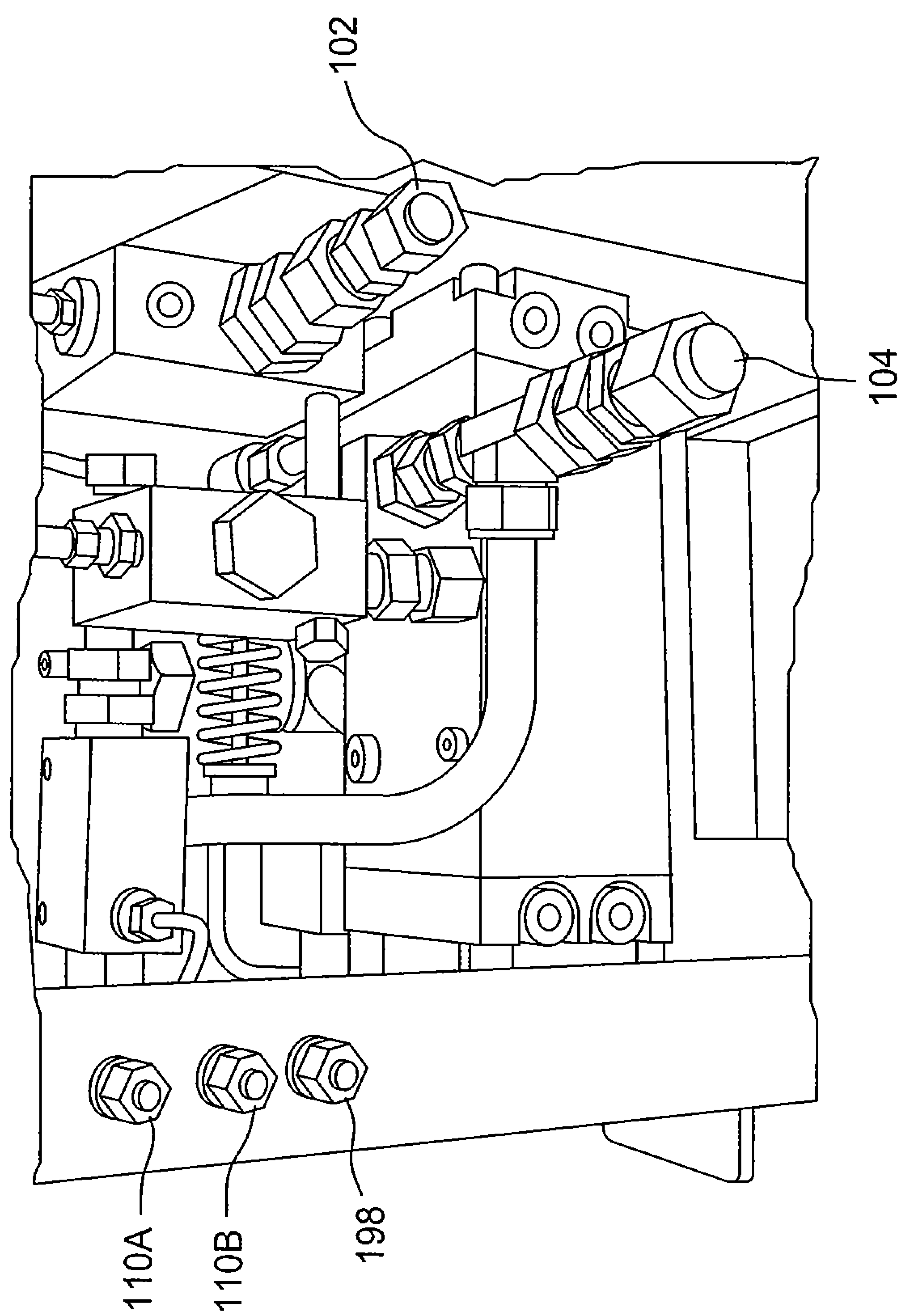

FIG. 7

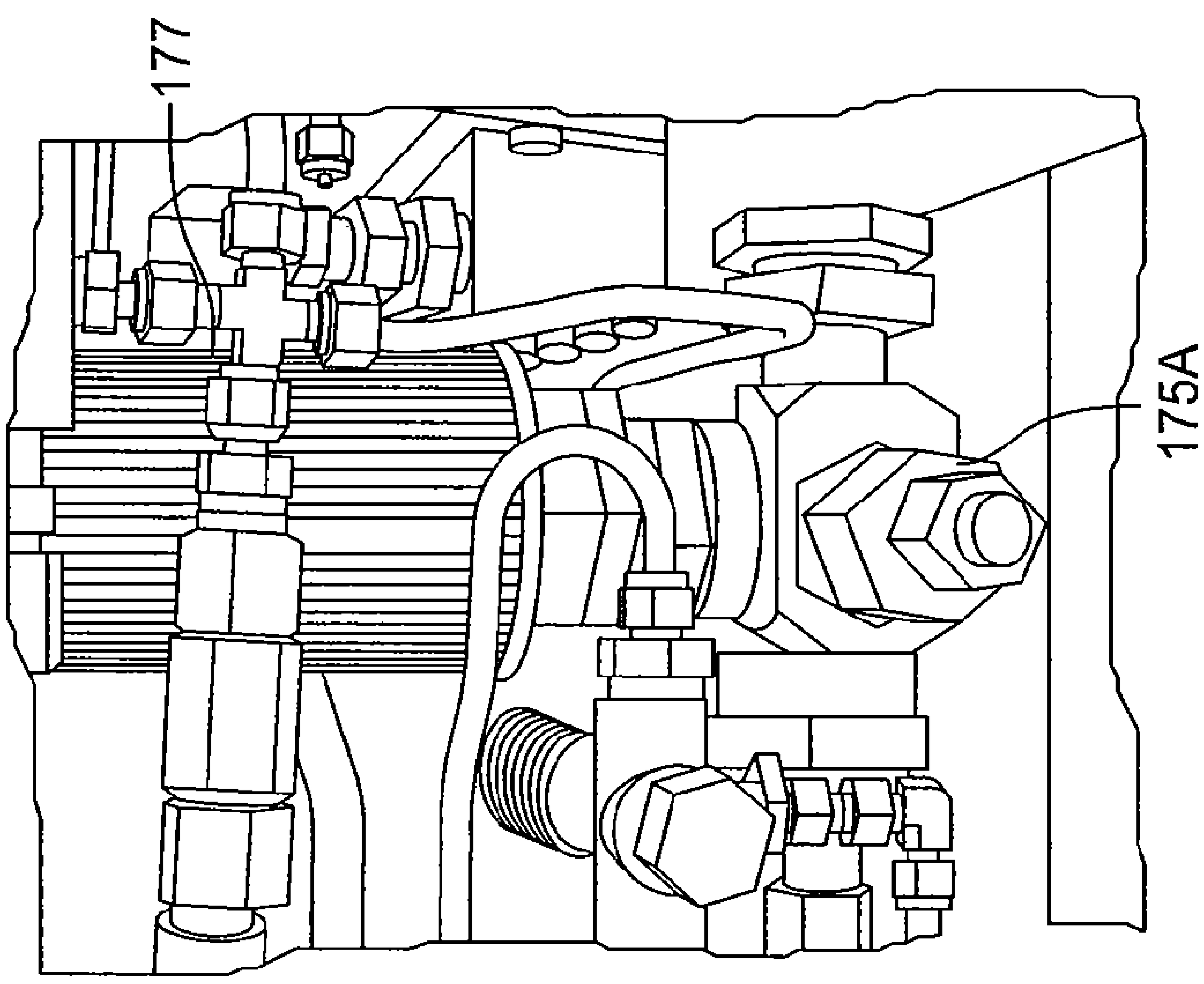

FIG. 9

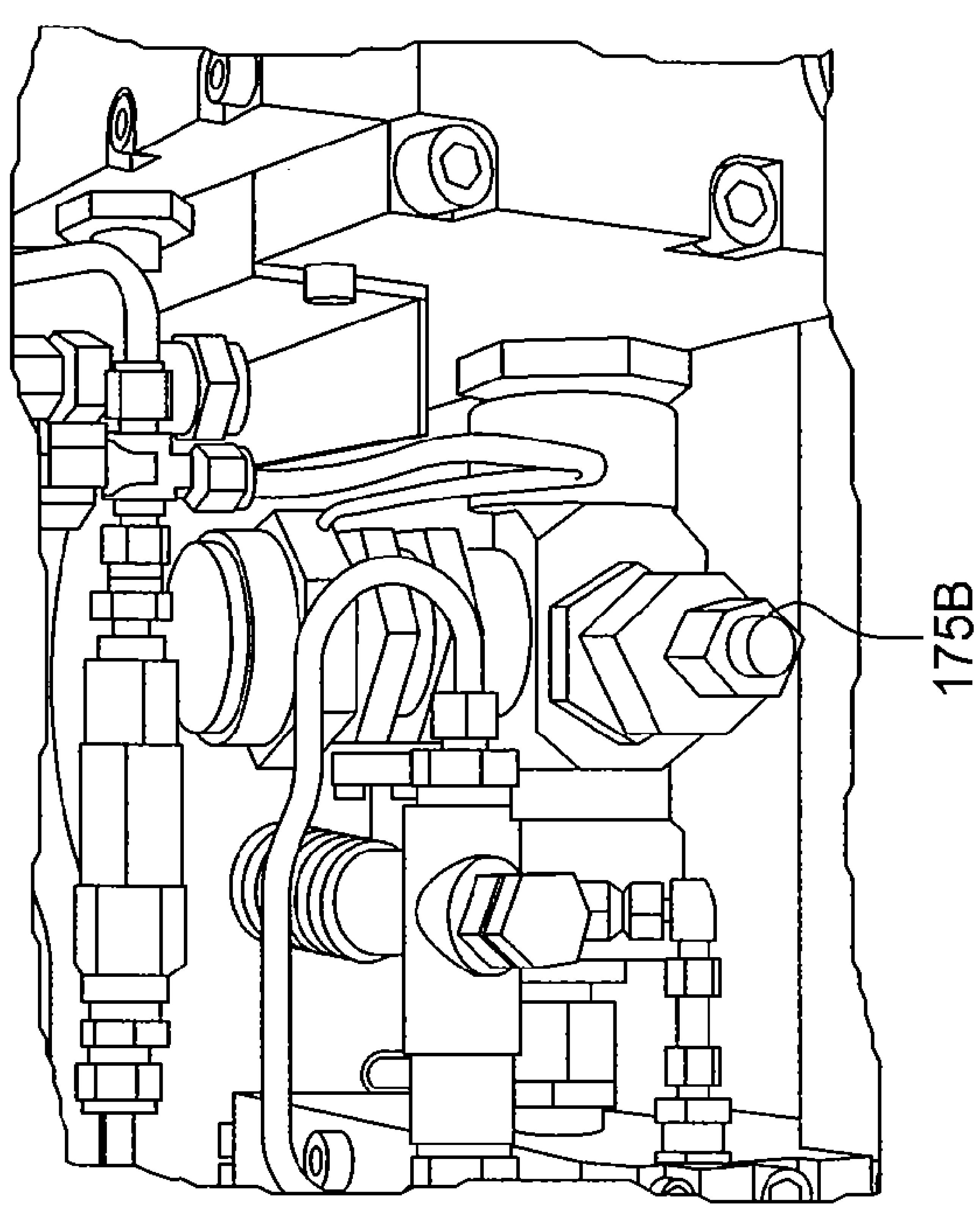

FIG. 8

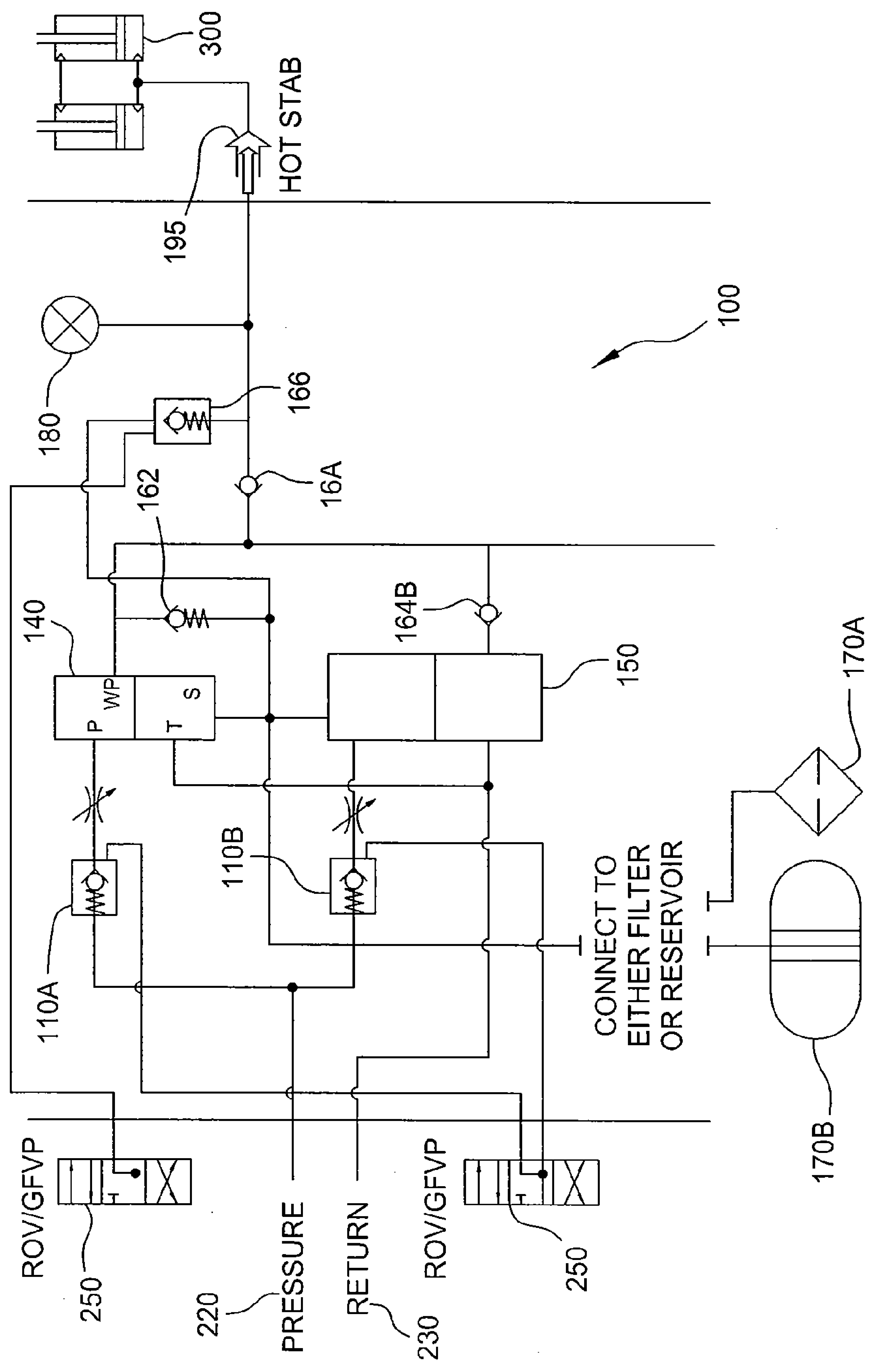
300
HOT STAB
195
180
166
16A
162
100
140
P
WP
T
S
164B
150
170A
110B
110A
CONNECT TO
EITHER FILTER
OR RESERVOIR
170B
ROV/GFVP
250
PRESSURE
220
RETURN
230
ROV/GFVP
250

FIG. 10

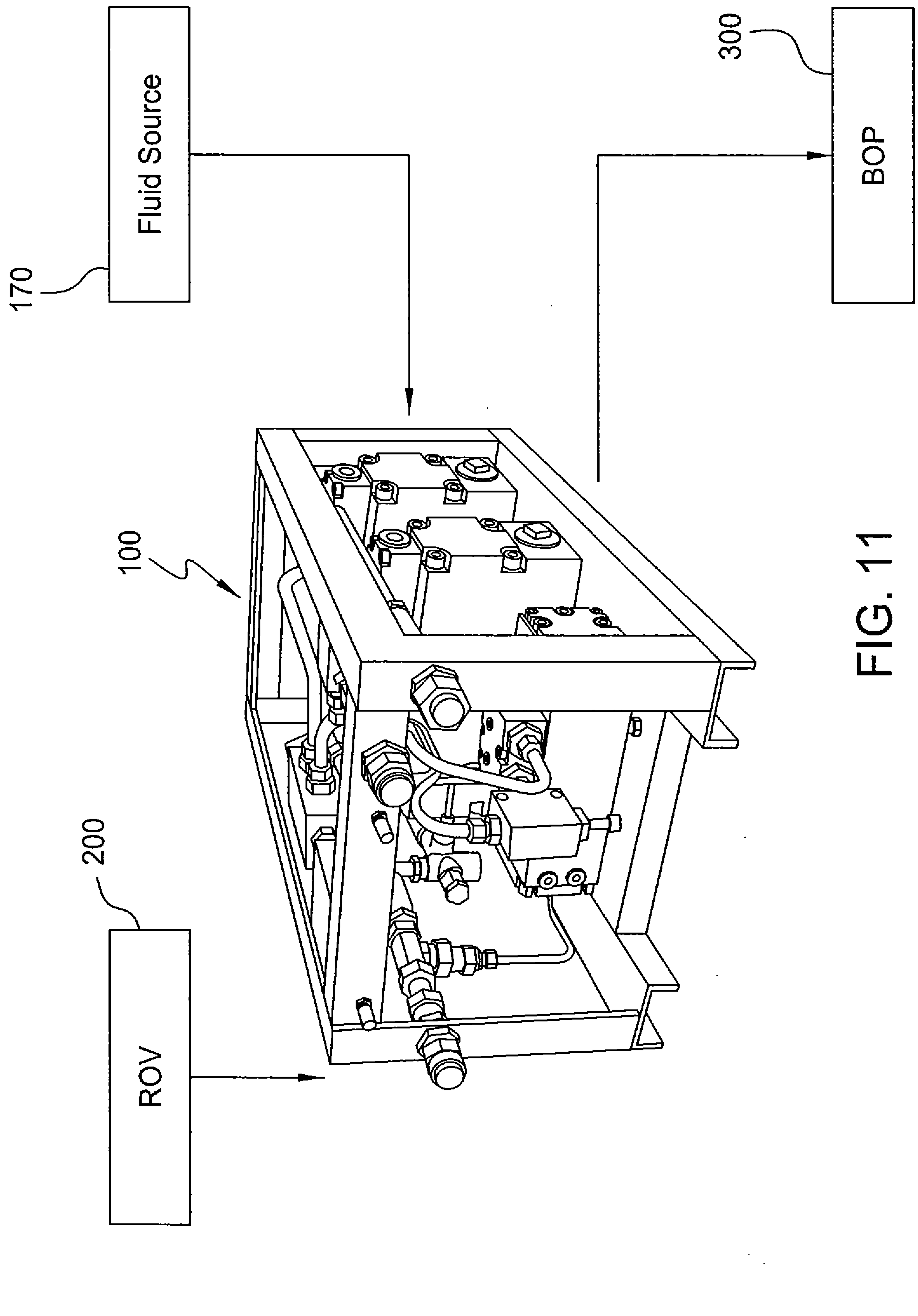

FIG. 11

BLOWOUT PREVENTOR ACTUATION TOOL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit to U.S. Provisional Application No. 61/557,556 filed on Nov. 9, 2011, which is herein incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Embodiments of the invention generally relate to a tool used in a subsea environment to help prevent the release of hydrocarbons into a body of water. More particularly, the invention relates to a tool that is connected to a remotely operated underwater vehicle ("ROV"), which provides a high flow rate of fluid at a high pressure to a blowout preventer ("BOP") to manually actuate the BOP.

2. Description of the Related Art

A blowout preventer ("BOP") is a large piece of specialized oilfield equipment that is used to seal, control and monitor oil and gas wells. In a subsea environment, the BOP is attached to the top of the wellhead at the bottom of the ocean. The BOP then connects to an offshore rig through a drilling riser. Drill strings are lowered inside the drilling riser and through the BOP and rotated by equipment on the offshore rig to turn a drill bit and drill an oil and/or gas well.

As an oil and gas well is being drilled, the well can receive what is called a formation kick, which is a burst of high pressure that comes from the reservoir. These kicks can cause a variety of catastrophic events, such as drill pipe and casing being blown out of the wellbore, and, in severe cases, hydrocarbons being released into the ocean. The BOP is designed to prevent these catastrophic blow outs from occurring, or at the very least, to minimize their effects when they do occur.

Typically, when a kick occurs, the BOP is closed so that fluids do not flow out of the wellbore. More specifically, rams or shears in the BOP are closed which effectively close and seal the drilling riser, drill strings and associated piping that runs through the BOP. The BOP rams or shears are closed remotely, either by workers actuating the BOP from an offshore rig or by an automated actuation system.

When the BOP cannot be actuated remotely, there is a need for an apparatus, system and method of manually actuating a BOP at a rapid speed in the event the BOP cannot be remotely actuated.

SUMMARY OF THE INVENTION

The invention relates to a tool, method and system for actuating a blowout preventer ("BOP") in a subsea environment. In one embodiment, a tool for actuating a BOP includes one or more connections for receiving hydraulic power from a remotely operated vehicle ("ROV"), a first pump for increasing pressure of an operating fluid for the BOP, a second pump for increasing flow rate of the operating fluid, and a conductor for transporting the operating fluid to the BOP.

In one embodiment, a method of actuating a BOP includes hydraulically connecting the tool to the ROV, pumping a fluid through the tool, increasing pressure and flow rate of the fluid, connecting the tool to a BOP, and conducting fluid from the tool to the BOP until the BOP is fully actuated.

In one embodiment, a system of actuating a BOP includes an ROV, a fluid source, and a tool having one or more pumps, wherein the tool uses hydraulic power from the ROV to operate the one or more pumps, and wherein the tool increases pressure and flow rate of the fluid source and conducts the fluid source to the BOP until the BOP is fully actuated.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features of the invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

FIG. **1** is a perspective view of an embodiment of a tool used to close a blow out preventer ("BOP"), which shows various connections used to connect the tool to a remotely operated underwater vehicle ("ROV") and includes one high pressure pump and two high flow pumps.

FIGS. **2** and **3** are schematics of the tool shown in FIG. **1**, wherein FIG. **2** illustrates the tool when the pumps use seawater, and wherein FIG. **3** illustrates the tool when the pumps use a fluid housed in one or more reservoirs to actuate a BOP.

FIG. **4** illustrates two connections of the tool, which are used when fluid, other than seawater, is pumped by the tool.

FIGS. **5**A and **5**B illustrate a connection of the tool and a filter needed when seawater is pumped by the tool.

FIG. **6** is a perspective view of an embodiment of the tool, which includes one high pressure pump and one high flow pump.

FIG. **7** is a perspective view of the embodiment of the tool shown in FIG. **6**, which shows various connections used to connect the tool to the ROV.

FIGS. **8** and **9** illustrate connections of the tool shown in FIGS. **6** and **7** to the fluid source: gloycol/oil and seawater, respectively.

FIG. **10** is a schematic of the embodiment of the tool shown in FIGS. **6**-**9**.

FIG. **11** is flow diagram showing a system for closing a BOP.

DETAILED DESCRIPTION

In one embodiment, a tool enables a blowout preventer ("BOP") to be rapidly closed such as when the BOP cannot be closed by a remote means. The tool may be mounted to a remotely operated underwater vehicle ("ROV"), and the ROV provides hydraulic power to the tool. The tool is further connected to the BOP, such as by use of a hot stab connection, and is configured to push fluid to the BOP in order to actuate the BOP. The tool includes a high pressure pump and one or more high flow pumps. The tool first runs fluid through one or more high flow pumps until the fluid reaches a predetermined (elevated) pressure, and then switches the fluid flow to a high pressure pump. Because the tool is able to rapidly increase the pressure and flow rate of the fluid flowing to the BOP, the BOP may be closed at a rapid speed. In one embodiment, the tool of the present invention can fully actuate most BOPs in under 60 seconds, thereby sealing the wellbore and protecting the wellhead equipment and environment from further damage.

FIG. **1** is a perspective view of an embodiment of the tool **100** used to close the BOP **300** (shown in FIG. **11**), and shows various connectors used to connect the tool **100** to the ROV **200** (also shown in FIG. **11**), as well as several components of the tool **100**. This embodiment of the tool **100** includes one high pressure pump **140** and two high flow pumps **150**A, B. The tool **100** receives hydraulic pressure from the ROV **200** via a line connected to a pressure connector **102**, and the tool **100** relieves any excess pressure via an ROV line connected to a return connector **104**. The ROV **200** is also connected to two pilot operated check valves **110**A, B, which may allow the hydraulic pressure from the ROV to reach either the high pressure pump **140** or the two high flow pumps **150** A, B. The pumps **140**, and **150**A, B in turn, use the hydraulic pressure from the ROV **200** to pump a fluid **170** (shown in FIGS. **2** and **3**) to the BOP **300**. In the preferred embodiment, a first end of a hot stab is connected to a BOP connector **190** of the tool **100**, and a second end of the hot stab is connected to the BOP **300**.

FIGS. **2** and **3** are detailed schematics of embodiments of the tool **100** shown in FIG. **1**, wherein FIG. **2** illustrates the tool **100** when seawater **170**A is the fluid pumped to the BOP **300**, and wherein FIG. **3** illustrates the tool when a fluid **170** housed in one or more reservoirs, such as hydraulic fluid including glycol or oil **170**B, is the fluid pumped to the BOP **300**. The operation of the tool in FIGS. **2** and **3** are substantially similar except where noted. The tool **100** has a pressure connector **102** for connection with a pressure line **220** from the ROV **200** and a return connector **104** for connection with a return line **230** from the ROA **200**. The tool **100** may also be connected to the ROV **200** using an ROV general function valve pack ("ROV GFVP") **250**. The ROV GFVP **250** communicates with at least two pilot operated check valves **110**A, B of the tool **100**, and provides hydraulic power to one of the pilot operated check valves **110**A, B at a given time.

When the tool **100** is initially used, the ROV GFVP **250** routes hydraulic power to the pilot operated check valve **110**B located upstream of a flow priority valve **120** and to high flow pumps **150**A, B. The hydraulic pressure opens the pilot operated check valve **110**B and allows the hydraulic pressure to flow to the flow priority valve **120**. Once hydraulic pressure upstream of the flow priority valve **120** reaches a minimum pressure set by the flow priority valve **120**, the valve **120** opens and allows the hydraulic pressure to operate the high flow pumps **150**A, B. In one embodiment, the flow priority valve **120** is a flow divider valve, and the flow priority valve **120** ensures that each high flow pump **150**A, B receives enough fluid to maintain even running of both pumps **150**A, B. An exemplary high flow pump **150** for use in the tool **100** of the present invention is a Dynaset HPW 90/150-85 pump.

The high flow pumps **150**A, B use the hydraulic pressure to pump the fluid **170** out to the BOP **300**, and in one embodiment, through a hot stab connection **195**. A check valve **164** ensures the fluid **170** does not flow back to the high flow pumps **150**A, B. A gauge **180** on the downstream side of the high flow pumps **150**A, B, and upstream of the BOP output **190**, allows pressure of the fluid **170** to be monitored. As the fluid **170** circulates through the high flow pumps **150**A, B, and out to the BOP **300**, flow rate and pressure of the fluid **170** increases.

The fluid **170** may be seawater **170**A, glycol **170**B, or any other oil or fluid appropriate for subsea operations. If the fluid **170** is glycol **170**B or any other oil, such fluid **170**B is stored in reservoirs near the tool **100**. The fluid is then connected via appropriate hoses to fluid connectors **175** in the tool **100**. Examples of these fluid connectors **175**A, B, which are attached to the pumps **140**, **150** of the tool **100**, are shown in FIG. **4**. If the tool **100** uses seawater **170**A as the fluid **170**, the same fluid connectors **175** (as shown in FIG. **4**) are used to receive the seawater **170**A, but a filter hose assembly **177**, shown in FIGS. **5**A and **5**B, may be attached to the fluid connector **175**. In one embodiment, the tool **100** may use both seawater **170**A and glycol **170**B (or any other oil or fluid appropriate for subsea operations). For example, the tool **100** may initially use glycol **170**B. Once the glycol **170**B is substantially depleted, a valve, which may be hydraulically operated, can be adjusted to allow the tool **100** to operate using seawater **170**A.

Turning back to FIGS. **2** and **3**, the hydraulic pressure of the ROV **200** (shown in FIG. **11**) may be shifted away from the high flow pumps **150**A, B to the high pressure pump **140** by opening the pilot operated check valve **110**A that is located upstream from the high pressure pump **140**. In one embodiment, the ROV GFVP **250** routes the hydraulic pressure from the pilot operated check valve **110**B to the pilot operated check valve **110**A. As a result, the check valve **110**B closes, and the hydraulic pressure from the pressure line **220** may no longer circulate to and operate the high flow pumps **150**A, B. After this shift, hydraulic pressure is only provided to the high pressure pump **140**.

After pilot operated check valve **110**A is opened, the hydraulic pressure from the ROV **220** flows through a flow control valve **130** to the high pressure pumps **140**. An exemplary high pressure pump **140** for use in the tool **100** of the present invention is a Dynaset HPW 520/30-85 pump. The hydraulic pressure supplies the power to the high pressure pump **140** to pump the fluid **170** out to the BOP **300**, preferably through a hot stab connection. A relief valve **162** is located downstream of the high pressure pump **140** to relieve fluid pressure from the system should the pressure exceed a specified pressure (preferably, the maximum pressure on the system is 5,000 psi). The check valve **164** prevents fluid **170** from flowing back to the high flow pumps **150**A, B. When the tool **100** includes one Dynaset HPW 520/30-85 high pressure pump and two Dynaset HPW 90/50-85 high flow pumps, the tool **100** can increase the pressure of the fluid from approximately 3000 psi to 7000 psi, and can increase the flow rate of the fluid from approximately 100-150 L/min to 200-300 L/min.

FIG. **6** is a perspective view of yet another embodiment of the tool **100**, which comprises one high pressure pump **140** and one high flow pump **150**. This embodiment operates in substantially the same manner, and is configured substantially the same as the embodiment shown in FIGS. **1-5**.

FIG. **7** is another perspective view of the embodiment of the tool **100** shown in FIG. **6**, which shows various connections used to connect the tool **100** to the ROV **200**. The same hydraulic connections shown in FIG. **1** are shown in FIG. **7**, with the addition of an optional depressurization valve **198**. The depressurization valve **198** is used to bleed hydraulic pressure off of the tool **100** after the tool **100** has completely actuated the BOP **300**. Furthermore, the depressurization valve **198** may be incorporated into the tool **100** shown in FIGS. **2** and **3**, and used for the same purpose.

FIGS. **8** and **9** illustrate the fluid connections **175**A, B of the tool **100** that receive the hoses that carry fluid **170**. Similar to FIG. **4**, FIG. **8** shows the basic fluid connector **175**B that is used for glycol, oil, and other fluids **170**B kept in a reservoir. Similar to FIGS. **5**A and **5**B, FIG. **9** shows the fluid connector **175**A connected to the filter hose assembly **177** when seawater **170**A is used in the tool **100**. In one embodiment, the tool **100** may use both seawater **170**A and glycol **170**B (or any other oil or fluid appropriate for subsea operations). For example, the tool **100** may initially use glycol **170**B. Once the glycol **170**B is substantially depleted, a valve, which may be hydraulically operated, can be adjusted to allow the tool **100** to operate using seawater **170**A.

FIG. **10** is a schematic of the embodiment of the tool **100** shown in FIGS. **6-9**. The embodiment of this tool is substantially similar to the embodiment of the tool **100** shown in FIGS. **1-5**, except, as discussed, this embodiment of the tool **100** contains only one high pressure pump **140** and one high flow pump **150**. In addition, a flow control valve is located downstream of each check valve **110**A, B, and upstream of the high flow pump **150** and the high pressure pump **140**. Also, instead of one check valve being used downstream of the high flow pump **150**, several check valves **164**A, B are placed downstream of the high flow pump **140**. These valves **164**A, B ensure fluid pressure is not removed from the system. In addition, a depressurization valve **166** is placed downstream of the pumps **140**, **150**, which allows the tool **100** to relieve all of the hydraulic pressure after the BOP **300** has been fully actuated. In one embodiment, the depressurization valve **166** may be manually operated. In one embodiment, the depressurization valve **166** may be remotely operated or operated by the ROV GFVP **250**. The same ROV GFVP **250** used to operate the pilot check valves **110**A, B may be used, or a different ROV GFVP **250** may be used to operate the depressurization valve **166**. Otherwise, the tool **100** shown in FIGS. **1-5** operates substantially identical to the tool **100** shown in FIGS. **6-10**. When the tool **100** is configured with one Dynaset HPW 520/30-85 high pressure pump and one Dynaset HPW 90/50-85 high flow pump, the tool **100** can increase the fluid pressure from approximately 3000 psi to 7000 psi, and can increase the flow rate from approximately 35-85 L/min to 70-150 L/min.

The tool **100** may be configured as a component that can be bolted onto the ROV **200** directly, along with reservoirs for holding fluid **170** if desired, or the tool **100** may be placed on a skid and used on or near the ROV **200**, depending on the ROV configuration.

In one embodiment, the method of actuating a BOP **300** includes hydraulically connecting an upstream side of a tool **100**, such as the tool **100** disclosed above, to an ROV **200**, and connecting a downstream side of the tool **100** to the BOP **300**. Initially, hydraulic power from the ROV **200** is used to operate one or more high flow pumps **150**A, B contained within the tool **100**, and after the pressure of the fluid **170** being pumped through the tool **100** to the BOP **300** reaches 1300-1500 psi, the hydraulic power is switched to operate the high pressure pump **140** within the tool **100**. In the preferred method of the invention, if the pressure of the fluid **170** drops below 1300 psi during operation of the high pressure pump **140**, the hydraulic power is switched back to operate one or more high flow pumps **150**A, B within the tool **100**. After the BOP **300** is fully actuated, the tool **100** is disconnected from the BOP **300**, and then depressurized by activating a depressurization valve **198** and allowing the pressure to bleed off, for example, to atmosphere.

FIG. **11** is flow diagram showing an embodiment of a system for closing the BOP **300**. In the system, the ROV **200** supplies hydraulic power to the tool **100**, and the tool pumps fluid **170** from an external source out to the BOP **300**. The tool **100** uses a high pressure pump **140** and one or more high flow pumps **150**, which in turn increases the pressure and flow rate of the fluid **170** being pumped to the BOP **300**. Because the fluid **170** is pumped to the BOP **300** at a high pressure and flow rate, the BOP is able to be fully actuated at a rapid speed.

While the foregoing is directed to embodiments of the invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

The invention claimed is:

1. A tool for actuating a blow out preventer ("BOP"), the tool comprising:

one or more connections configured to receive fluid power from a remotely operated vehicle ("ROV");

a fluid powered high pressure pump fluidly connected to the one or more connections and configured to increase pressure of an operating fluid for the BOP;

a fluid powered high flow pump fluidly connected to the one or more connections and configured to increase flow rate of the operating fluid, wherein the high flow pump is configured to pump the operating fluid to the BOP until a predetermined pressure is reached, wherein once the predetermined pressure is reached, the fluid power is shifted from the high flow pump to the high pressure pump via the one or more connections; and

a conductor configured to transport the operating fluid to the BOP.

2. The tool of claim **1**, wherein the fluid power is hydraulic power used to operate high pressure and high flow pumps.

3. The tool of claim **2**, wherein the hydraulic power is shifted to alternately operate the high pressure and high flow pumps.

4. The tool of claim **1**, wherein the tool comprises at least two fluid powered high flow pumps.

5. The tool of claim **1**, wherein once pressure falls below the predetermined pressure, the fluid power is shifted from the high pressure pump to the high flow pump.

6. The tool of claim **1**, wherein the tool further comprises a valve fluidly connected to the one or more connections and configured to direct the fluid power from the ROV to at least one of the high pressure pump and the high flow pump.

7. The tool of claim **1**, wherein the operating fluid is seawater.

8. The tool of claim **1**, wherein the operating fluid is hydraulic fluid.

9. A method for actuating a blow out preventer ("BOP"), comprising:

fluidly connecting a remotely operated vehicle ("ROV") to a tool, wherein the tool includes a high flow pump and a high pressure pump;

fluidly connecting the tool to the BOP;

powering the high flow pump to increase a flow rate of an operating fluid pumped by the high flow pump to the BOP until a predetermined pressure of the operating fluid is reached;

once the predetermined pressure of the operating fluid is reached, shifting power from powering the high flow pump to powering the high pressure pump to further increase the pressure of the operating fluid; and

conducting the operating fluid from the tool to the BOP to actuate the BOP.

10. The method of claim **9**, wherein the ROV supplies hydraulic power to one or more high flow pumps of the tool until the operating fluid reaches the predetermined pressure.

11. The method of claim **10**, further comprising shifting the hydraulic power from the one or more high flow pumps to the high pressure pump after the operating fluid reaches the predetermined pressure.

12. The method of claim **9**, further comprising shifting power from the high pressure pump to the high flow pump if pressure of the operating fluid drops below the predetermined pressure.

13. The method of claim **9**, further comprising disconnecting the tool from the BOP after the BOP is fully actuated.

14. The method of claim **13**, further comprising depressurizing the tool after the tool is disconnected from the BOP.

15. The method of claim **9**, further comprising filtering the operating fluid.

16. A system for actuating a blow out preventer ("BOP"), comprising:

a remotely operated underwater vehicle ("ROV"), and a tool fluidly connected to the ROV, wherein the ROV is configured to power one or more pumps of the tool to increase pressure and flow rate of fluid from a fluid source to the BOP until the BOP is fully actuated, and wherein the tool is movable between a first position in which the tool is connected to the BOP and a second position in which the tool is disconnected from the BOP.

17. The system of claim **16**, wherein the one or more pumps include at least one high pressure pump configured to increase pressure of the fluid from the fluid source and at least one high flow pump configured to increase flow rate of the fluid from the fluid source.

18. The system of claim **17**, wherein a valve directs the power to either the at least one high pressure pump or the at least one high flow pump.

19. A method for actuating a blow out preventer ("BOP"), comprising:

connecting an actuation tool to the BOP;

supplying power from a remotely operated underwater vehicle ("ROV") to the actuation tool;

increasing a pressure and a flow rate of an actuation fluid pumped by the actuation tool;

supplying the actuation fluid from the actuation tool to the BOP to actuate the BOP; and

disconnecting the actuation tool from the BOP once the BOP is fully actuated.

20. The method of claim **19**, wherein the ROV hydraulically powers the actuation tool.

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